The Canadian Entomologist

Vol. LXXXI July 1949 No. 7

Biological and Ecological Studies on Some Lepidopterous Bud and Shoot Insects of Jack Pine (Lepidoptera-Olethreutidae)[1]

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Injury to young jack pine in an experimental plantation at Cloquet, Minn., by a shoot boring insect, *Eucosma sonomana* Kearfott, stimulated the investigations on life history, biology and incidence reported here. Notes on life history, biology and injury are included for two additional species of the subfamily Eucosminae, family Olethreutidae; namely *Petrova albicapitana* Busck, and *Petrova pallipennis* McDunnough.

The plantation in which these studies were carried on was part of an experimental seed source study being conducted by T. S. Hansen, professor of Forestry at the University of Minnesota, and director of the Cloquet Forest Experiment Station.

An analysis of the importance of the three insects under consideration is facilitated by the presence at Cloquet of a history of each tree in the plantation. Annual records of tree size, form, insect injury, etc. have been made for each tree since the plantation was established, and the information on attack has proved useful in this study with respect to assessing the past and potential injury caused by these insects.

History and Distribution of the Three Species in Minnesota

The presence of *Eucosma sonomana* Kearfott in northern Minnesota was first acknowledged in the Minnesota Forest Insect and Disease Survey for 1942. At that time, Hodson and Christensen (1942) referred to this insect as causing light damage in two plantations, one at Thistledew Lake and one at Roy Lake, Minnesota. In a similar report Hodson and Christensen (1945) reported that plantations and natural reproduction were heavily infested at Willow River, Bagley, Brainerd, Side Lake, Park Rapids, Brimson, Cloquet, and Itasca Park. These references were made from inspection of injury only, and at the time it was thought probable that the species was the Nantucket Pine Tip Moth, *Rhyacionia frustrana* Busck. In 1946-47, adult specimens were reared and preliminary identification made with the assistance of Dr. H. E. Milliron of the University of Minnesota, established that the insect belonged to the genus *Eucosma*. Adults were referred to Mr. C. Heinrich of the U.S. National Museum, who identified the species as *Eucosma sonomana* (Kearf.). In their Minnesota Forest Insect and Disease Survey Report for 1947, Hodson and Christensen (1947) note that heaviest damage was observed near Cass Lake and the Cloquet Forest Experiment Station. The degree of infestation was said to range from 15 to 70 per cent of the leaders killed.

It would appear that the presence of this insect was not discovered in this state until 1942, and that the true identity of the species causing the injury to be described is herein established for the first time.

Petrova albicapitana has been present in Minnesota for some time, being recorded by Hodson and Christensen in their Forest Insect Survey Report as

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early as 1939. It appears to be present in all the areas where jack pine is grown in the state. It has also been observed in Wisconsin and on the Upper Peninsula of Michigan.

Petrova pallipennis was first described by McDunnough (1938) from specimens collected in Wright, Quebec; Tyrile, Manitoba; and Nordegg, Alberta. So far as is known the specimens collected in several localities in Minnesota by the writer are the first to have been found in the United States.

Eucosma sonomana was first described by W. D. Kearfott (1907). At that time, three males and one female were collected in Sonoma County, California, and Carmel-by-the-Sea, Monterey County, California. Heinrich (1923) in his revision of the Eucosminae notes that five specimens are in the National Collection from Missoula, Montana, having been reared from *Pinus ponderosa* and *Picea engelmanni* terminals.

The insect was found in numerous areas where jack pine occurs in Minnesota, and has been observed in plantations and natural reproduction at Cass Lake, Willow River, St. Croix Park, Green Valley, Sturgeon Lake, and Brainerd. In addition, scattered injury was found at Laona, Wisconsin; Kenton, Michigan; and Iron River, Michigan.

The above notes on distribution would extend the known range of this insect considerably east of Montana where it was last collected by U.S. National Museum workers in 1915 and 1916 (Heinrich, 1923). While there was no opportunity for observing jack pine east of Lake Michigan, unverified reports of its presence have been received from there.

Petrova albicapitana appears on jack pine in all the areas where *Eucosma sonomana* has been found. Distribution of this insect is general throughout the range of jack pine in Minnesota, Wisconsin and Michigan, and Canada. *Petrova pallipennis* has been observed in the Sturgeon Lake and Willow River areas in addition to Cloquet in Minnesota. Injury by this latter species is not likely to attract as much attention as the other two, consequently records are not as complete. Neither of the above two insects has been observed on any host but jack pine in the Lake States.

Life History of *Eucosma sonomana* (Kearf.)

The life history studies of this species, reported here, represent accumulated observations made at the Cloquet Forest Experiment Station during a period from June 17 through August 25 of 1947, and during the spring and early summer of 1948. No adults of this species were obtained in any of the collecting trips made subsequent to June 17, 1947. It was only possible, then, to assume that adult activity had taken place prior to this date.

In 1948, the above conclusion was supported by receipt of adults of this species which were collected in the field on May 13. It might be well to point out that the 1948 growing season was more advanced than that of 1947, and reference to the phenological picture in terms of shoot growth for the two years readily shows that adult activity probably would have occurred before June 17, the date when the study was initiated in 1947. The phenological data were obtained by recording the length of elongating leaders at 7-day intervals. This made it possible to interpret occurrences in the light of seasonal growth behavior. On June 10 of 1948, as shown by the amount of shoot elongation, new growth was already ahead of that for similar growth on June 17 of 1947. This indicates that in 1948 terminal growth began from 7 to 14 days earlier than in the previous year. If this is to be accepted as indicative, it must be assumed that emergence of *Eucosma sonomana* in 1947 occurred between the third week in May and the

first week in June, peak emergence probably occurring in the latter part of May. In 1948, according to field collections, adult activity was at its maximum during the middle of May.

Egg Laying and the Duration of the Egg State

Eggs of *E. sonomana* were never observed under natural conditions in the field. Adults of this species that emerged in the laboratory were paired and placed in petri dishes with jack pine needles. In only rare instances were eggs laid, and under such artificial conditions it is unwise to state categorically that oviposition would occur in a similar manner in the field. It was observed in those cases where the eggs were found in the laboratory, however, that they were invariably glued to the needle sheath. This light reddish-orange basal covering of the needles serves as excellent camouflage for the eggs. Indeed, it would be virtually impossible to observe them in the field without the aid of a lens, and then only if one knew where to look. Unfortunately, it was never possible to be in the field at the time of oviposition, so it cannot be said for certain that the eggs are laid in the same place under field conditions. The eggs discovered in the laboratory were on the average 0.3 of a millimeter in diameter, flattened, and circular to elliptical in outline, and were appressed tightly to the needle sheath. It is quite possible that in nature they are appressed to the inner side of the needles, which would minimize the larval activity necessary for movement to, and penetration of the shoot proper.

The duration of development is of course not known, since this phenomenon could not be observed in the field. None of the eggs hatched in the laboratory. However, since we are reasonably certain that adult activity lasted from May 13 to May 24, approximately, the peak being around the 19th, we can figure the duration of the egg stage as being from 2 to 4 weeks. A visit to Cloquet on June 11, 1948 disclosed no eggs, but numerous first instar larvae were dissected from the bark of freshly cut shoots. In several cases, the larvae had just succeeded in penetrating the outer surface of the shoot, and microscopic examination disclosed the fresh entrance hole in close approximation to the needle sheath. In many cases, the larvae were recovered before they had reached the pith. There is no doubt that these were first instar larvae which had made their way into the shoot within the last 72 hours. Thus, if we assume that the time of maximum adult activity occurred around May 19, and that larval hatching was completed by June 11, it seems reasonable to assume an incubation period of 3, or possibly 4 weeks.

Larval Stage

As mentioned earlier, in 1948 first instar larvae were recovered from new shoots on June 11 at Cloquet. In 1947, the first larva was noticed on June 25. Extensive samplings were not made until early in July, at which time virtually all the larvae taken were second or third instar. It would seem from the foregoing that larval activity in 1947 occurred approximately two weeks later than it did in 1948, which is about what might be expected from an interpretation of the phenological picture based on shoot elongation. The larval instar determinations in this study were made from head capsule measurements employing a modification of Dyar's method, in which the head capsule measurement was made at its widest point—across the apex of the epicranial suture. The first instar, which was identified beyond any reasonable doubt, possessed a head capsule measurement of 0.3 to 0.5 mm. The complete tabulation of instar measurements, based upon some 160 larvae, follows:

1st instar	0.3 to 0.5 mm.
2nd instar	0.8 to 0.9 mm.

3rd instar	1.0	to	1.25 mm.
4th instar	1.3	to	1.40 mm.
5th instar	1.48	to	1.55 mm.

From the above figures it seems reasonable to assume that five instars are normal for this species. Of course, such a method of instar determination is merely a useful guide, and since it was impossible to obtain first instar larvae from eggs hatched in the laboratory, it was not found practical to attempt rearing operations. Because of the feeding habits of this species, such a study was not easily made.

The above data are substantiated in part by shoot dissections made on jack pine shoots brought into the laboratory. Infested shoots were collected after the larvae had emerged, and these were immersed in water for a period of several days. At the end of this time, the shoots were sliced open carefully, with particular care being taken to avoid disturbing the larval borings in the pith. Then, by using a binocular microscope, the pulverized pith was teased apart in search of cast larval skins. In most cases five such exuviae were found per shoot. Just often enough to be disturbing, six remnants were discovered. This technic was complicated by the presence at the initial entry point of numerous aborted first and second instar larvae, and not a little by the fact that the head capsules were rarely intact.

Larval Activity

The penetration of the first instar larvae into the shoot was studied in considerable detail from microscopic dissection of the new growth.

The majority of the larvae enter the shoot at a point 6 to 8 inches above the base of the current season's growth. At the point of penetration (almost invisible to the unaided eye) a tiny hole 0.3 mm. in diameter may be found. It would seem that the first instar larvae penetrate the epidermis by chewing their way in, and the first moult occurs after the larvae have made their way down approximately 1 inch. Moulting occurs in the pith. A number of larvae obtain entrance into the shoot, as high as five advanced larval instars having been taken from a single shoot at one time. In most cases, however, the larval exit holes (Figure 1) indicate that only 2 or 3 larvae are able to complete their development in the larger shoots, and often only one in the smaller.

As indicated above, larvae for the most part enter the shoot 6 to 8 inches above the base of the new growth. They then progress downward to a point 1 to 3 inches above the base of the current year's growth. At this point, the larva appears to reverse itself and proceeds 1.5 to 2 inches upward. All this time feeding has taken place in the pith, but now the mature larva proceeds to girdle the vascular tissue of the shoot, eating away all but the epidermis. From here, the larva proceeds upward another 0.5 to 2 inches and begins to bore the characteristic exit hole. The girdling described seems without doubt to bring about a rather rapid drying of the stem above and may be a precautionary measure to preclude the possibility of the trapping of the larva in pitch as it attempts to leave the shoot. The exit holes are never found unless this girdling has taken place.

Under insectary conditions emergence of mature larvae from the shoots took place only during mid-afternoon when indoor temperatures were highest.

Pre-pupal Stage

Under laboratory conditions, when the larva reached a secluded spot, a silken cocoon was spun. Within 24 hours, the larva began to turn a yellowish color in the thoracic region, and when prodded, only the abdomen seemed cap-

FIG. 1. Injured shoots showing emergence holes of the mature larvae.

able of movement. These abdominal movements resembled a typical pupal response. Sixty to seventy-two hours after the cocoon was first spun, the last larval skin was cast and the typical pupal form was visible.

Pupal Stage

E. sonomana overwinters in the pupal stage in the field. As indicated in the preceding discussion, the pre-pupal period is apparently of only 60 to 72 hours duration, after which pupation takes place, and adults do not appear at Cloquet until the second or third week in May. The larvae drop to the ground, seek a secluded spot in the litter and spin their cocoon. It has been observed in several instances that under natural conditions this cocoon becomes impregnated with small particles of sand and debris which makes it extremely difficult to find.

A limited number of pupae were retained at 70° F., and 100 percent relative humidity for 8 months subsequent to pupation in the field, without exposure to low temperatures, but none of these gave rise to adults. Those that were placed at 5° C. for a period of 3 to 3.5 months gave rise to adults within 8 days after being brought to room temperature. These data suggest the probability of a diapause which is broken by exposure to moderately low temperature.

Notes on the Life History of *Petrova albicapitana* and *P. pallipennis*

Notes on the life history of *Petrova albicapitana* occur in the literature (Caesar, 1917; Pettit, 1928). The latter suggests that this insect has a two-year life cycle, but on May 15, 1948 only pupae were to be found in the blisters, which would make it seem that development may be completed in one year.

In 1948 at Cloquet, all the nodules examined contained pupae by May 15, and adults were very numerous on June 11. The insect overwinters as a larva, and pupation took place as early as May 1 in 1948.

Not much information is available on the life history of *Petrova pallipennis*, but a few observations which were made from time to time will be presented here. In 1947, adults were observed in abundance on June 22 at Cloquet. At the same time, it was noted that most of the pupae remaining in the buds were parasitized. In 1948, adult emergence was noted on June 10 at Willow River. Adult activity was at a very low level by the end of June.

Eggs were never recovered in the laboratory or in the field.

Petrova pallipennis overwinters as a dormant larva. On April 2, 1948 at Willow River, larvae in the buds were mostly dormant, although a few were feeding. By May 2, 1948, all the larvae had pupated.

In 1947, buds collected in the field the first week in June all contained pupae. All of the infested buds contained pupae at Willow River by May 2, 1948. Pupae were still present in the field up until the third week in June, although most of those remaining at this date were parasitized.

Parasites

Eucosma sonomana

Only one species of parasite was recovered from those pupae taken into the laboratory for purposes of adult emergence. Of 80 borers which pupated and were not parasitized by fungi, 19 were parasitized by an Ichneumonid, representatives of which were identified by Dr. H. K. Townes of the U.S. National Museum as *Glypta sp.* No other record of parasitization was made by the writer, and as far as is known no other records exist on the subject.

Petrova pallipennis

Petrova pallipennis appears to be very susceptible to parasitization and, although no supporting evidence other than the record of parasitism is on hand, it is quite possible that the feeding habits of this species make it more subject to attack by predators and/or such natural controls as may arise, e.g., weather. In contrast to the larvae of *P. albicapitana* and *E. sonomana*, which spend their larval periods in the pitch blister and pith, respectively, *P. pallipennis* is necessarily exposed at frequent intervals without the covering of the bud as protection. These periods of vulnerability occur during the movement from one bud to the other.

Six different species of Hymenopterous parasites were recovered from pupae of *P. pallipennis* that were brought into the laboratory. These represent three different families, as follows:

ICHNEUMONIDAE (det. H. K. Townes)
- *Campoplex argenteus* (Prev.)
- *Diplazon tibiatorius* (Thbg.)
- *Phaeogenes* sp.
- *Calliephialtes comstockii* (Cr.)

BRACONIDAE (det. C. F. W. Muesebeck)
- *Apanteles petrovae* (Walley)

CHALCIDIDAE (det. H. E. Milliron)
- *Eurytoma* sp.

The above parasites were recovered from pupae which were collected in the spring of 1947, during which period the population of *P. pallipennis* appeared to be experiencing a decline. Observations made on June 25, when aborted buds were collected and taken into the laboratory for dissection, showed that 36 out of 38 pupae were either parasitized by hymenopterous larvae, diseased or killed by some other agency.

Again on June 25 at Cloquet, of 19 buds dissected, 18 contained parasitized pupae and in only one was the pupa uninjured. Similar observations made at Willow River, Minnesota on May 2, 1948, at which time an examination of 18 aborted buds revealed that 6 of the 18 were parasitized by one of the above mentioned hymenopterous parasites.

Plantation survey records of parasitism of this species in 1947 contain numerous references to parasitized pupae. These figures are not reliable for use in a statistical treatment of parasite incidence, because it was only infrequently that the aborted buds were dissected in order to determine whether or not the pupae were intact. It does seem reasonable, however, to interpret the frequent records of parasitism found in the plantation survey report as indicative of a high percentage of parasitism.

Petrova albicapitana

Dissection of pitch blisters in routine observations on feeding and development of the larvae of *Petrova albicapitana* has shown very little parasitism. In all, no more than half a dozen instances were recorded where parasites had been found, and this in a volume of observations that runs well into the hundreds. The tendency of the larvae to ensheath themselves in a pitch blister doubtless affords them some protection; possibly, too, the short pupal period contributes. At no time other than possibly the egg and adult stages is the insect exposed. As mentioned under life history of this species, the larvae feed continually surrounded by the blister or nodule, and when pupation takes place, it is accomplished within the blister. The pupal case is actually tightly packed within a fold in the blister itself, and a casual observer, unfamiliar with the habits of this species, might be inclined to feel that the larva had emerged from the blister. However, by careful dissection of the inner thickened portion, the pupa may be uncovered.

Only one species of parasite was recovered in the Cloquet area from pitch nodules. This insect was identified by Dr. H. E. Milliron as a Chalcid, *Hyssopus evetriae* (Gir.). The parasitized larval remnants which were presented to Dr. Milliron contained approximately eight pupae of this parasite. This condition was observed on several other occasions, indicating that superparasitism is not unusual in this species.

Description and Significance of Injury

Characteristics of injury by *Eucosma sonomana*

The work of *Eucosma sonomana* can be diagnosed most easily in the field after the larvae have girdled the shoot prior to emergence. At this time, if a strong wind is present, the shoot will snap over at the girdled portion and if the force of the breakage is strong enough, the portion above the girdling will fall free, leaving only 2 to 6 inches of the leader of lateral still remaining (Figure 2). This, for the most part, will comprise current year's growth, and serves as a useful diagnostic character. However, if girdling is not completed at the time the shoot blows over, the terminal portion is retained by a portion of the bark, and simply droops at a rather acute angle. Sometimes these shoots will persist in this condition until the following year.

As frequently happens, however, there is not enough wind movement to whip the top branches sufficiently to cause breaking. In such cases injury may be apparent from the tiny (2 to 3 mm. diameter) emergence holes. These branches, however, subsequently turn yellow and then brown, even though they still remain in a normal position. These are not easy to see while they are still green, and a sampling technic which was found to be very useful consisted of

FIG. 2. Breakage of a terminal shoot at point where girdling occurred.

shaking the trees vigorously, which in most cases was sufficient to break the girdled stems, while in no way injuring the tree. By the time the first snow falls in Minnesota, however, all those branches that have been girdled are broken over, and there is no difficulty in recognizing the damage.

Effect on the tree

Since jack pine is a rapidly growing tree in its early years, injury such as that caused by the shoot borer is not as serious in all cases as might be imagined from the nature of the damage. There is a pronounced tendency for the leader to be supplanted by one of the upper laterals the following year, which, while affecting the form of the tree for a few years, does not promise to have too great an effect upon the merchantability of the tree as mature timber. This is true, of course, if repeated attacks are not sustained, a contingency which frequently occurs. After breakage, the lower portion of the leader persists as a stub, which is only partially enveloped by the growing stem. Since this portion has no means of maintaining itself as a living part of the tree, it deteriorates and may serve as the entry point for parasitic organisms, preventing the development of a normal, straight, merchantable tree, and presumably weakening the tree so that breakage later on is possible. However, since the injury has not been studied sufficiently in the past, the long range effects of these attacks can only be surmised.

Laterals also are affected, but their loss would be of little importance with respect to tree form. If, however, a top lateral which might have taken the place of an injured leader is attacked, the injury does assume more significance.

While it is practically impossible to predict the ultimate effects of repeated attacks by this insect, many trees in the plantation under study at Cloquet have the characteristic bushy appearance symptomatic of persistent breakage of the terminal branches. This condition derives from the failure of any one lateral

to outstrip the others to the extent that it can be truly dominant. In these cases, a "mugho" bushy pine effect is created in which a number of the uppermost laterals are making about the same growth.

Characteristics of injury by *Petrova albicapitana*

The injury caused by this species has been described earlier by Caesar (1917) and Pettit (1928).

Effect on the tree

The immediate effect of *P. albicapitana* feeding does not appear to result in significant injury, although frequently every new shoot—leader and lateral—on the tree may have a pitch blister at its base; in most cases the larvae emerge and scar tissue forms which for all practical purposes repairs the damage. However, in many cases, feeding is not quite so superficial, and burrows penetrate into the pith. Cases have been observed where the base of the new growth has been chewed half through. When this occurs, the shoot may break soon after, or more often at some later time. Whereas in the case of *E. sonomana* a clean break results, and the terminal portion invariably dies, advanced *P. albicapitana* injury results in the terminal portion falling over, but not always dying. The effects of this contingency should not be minimized, because this deformed leader retains its dominance, and in most cases attempts to reassert itself from its new position. Scar tissue forms in the area which has been fed on, and the terminal portions of the shoot continue to grow upward from a deformed base. Obviously this condition, should it persist, mitigates against formation of a straight tree, and the groundwork has been laid for subsequent breakage at this point of weakness.

Characteristics of injury by *Petrova pallipennis*

First evidences of *P. pallipennis* injury are not apparent until the new shoots have begun to elongate in the spring. When normal growth becomes noticeable, those buds which have been attacked by *P. pallipennis* larvae remain static, and are conspicuous because they are outstripped by lateral shoots. The bud when examined closely shows a small round hole, generally close to the base, approximately 1.5 to 2.0 mm. in diameter, usually screened shut from the interior with a silken covering. If the buds are opened at this time, either a mature larva or a pupa will be found inside. Later on in the season, the bud softens and internal rot sets in. The following year, remnants of the bud still persist with alternate shoots having taken over.

Careful examination of the lateral buds after the larvae have emerged from the eggs may reveal somewhat smaller openings than those described above. If these buds are examined carefully, ultimately one will be reached which contains the small chocolate colored larva. This condition reveals itself only upon close examination, however, and is not a useful diagnostic character for the practical field worker.

Effect on the tree

The immediate effect of *P. pallipennis* injury arises from the failure of the terminal buds to develop. As a consequence, a crooked stem or "stag-head," results when an alternate shoot has to take over. The feeding habits of the immature larvae, which mine the lateral buds adjacent to the terminal bud, in many cases result in destruction of the entire whorl. Subsequent rotting of the bud can pave the way for a condition similar to that referred to in connection with *E. sonomana*, with possible structural weaknesses following later on.

Incidence and Build-up of *E. sonomana* over a Three Year Period, with Notes on Injury to Trees of Different Seed Source

Some measure of the ability of *Eucosma sonomana* to cause significant injury to jack pine, particularly when planted in pure stands such as is the case in the experimental plantation where these studies were made, is obtained from the analyses which follow.

Trees in this planting varied from 7 to 9 years of age as of 1947, and from 5 to 8 feet in height. Incidence of attack on trees of each of these three age categories (6725 trees) and each of the four size categories (3150 trees) was studied.

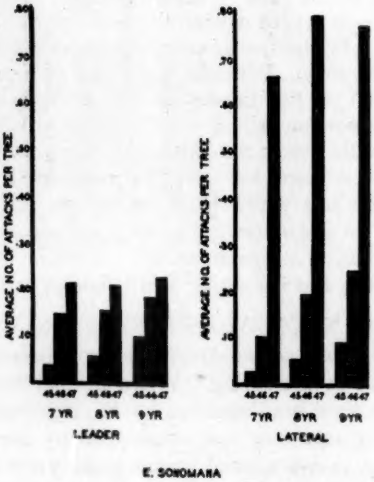

FIG. 3. Average number of attacks per tree on leader and lateral shoots for a three year period; trees seven, eight and nine years old.

The accompanying Figure 3 expresses in terms of average number of attacks per tree the injury to new growth of both leader and lateral shoots on trees of the above mentioned age categories. All categories show an increase in average number of attacks for each succeeding year of the three year period, and the older trees sustain the greater number of attacks per tree in all cases.

This straight line relationship of age to incidence of attack is substantiated by Figure 4 which plots tree size against incidence of attack. Leader and lateral shoot injury is not differentiated here, and the picture of heavier attacks on larger trees is the same. The conclusion would seem to be that the population within this planting is increasing as the number of laterals of a size adequate for larval development increases. It would appear that the capacity of this species for build-up in this situation is conditioned primarily by tree size, which expresses itself in terms of available food. The straight line relationship suggests that biological agencies, for example parasites and predators, are not greatly disturbing the trend of population increase. It would also seem that the population has not saturated its medium, in this case the small experimental plantation.

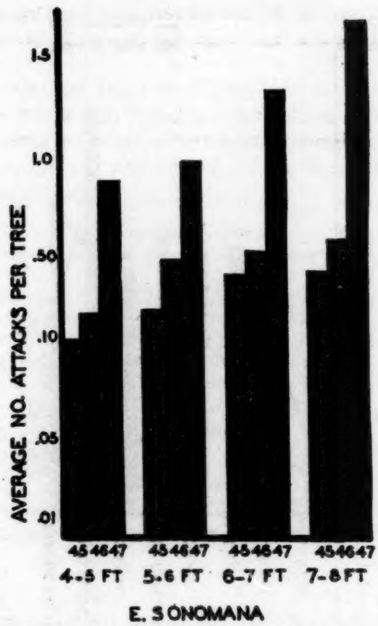

FIG. 4. Average number of attacks per tree on trees of four different height groups.

The trees in this experimental planting were grown from seed imported from a number of different geographical locations in the United States and Canada. The following seed lots are replicated to the extent that it is possible to get a picture of *E. sonomana* attack based upon no less than 400 trees in each category. 5,500 trees are included in the analysis.

Seed from the following locations was used:

Wellston, Michigan
Huron, Michigan
Chisholm, Michigan
Cloquet, Minnesota
Manistique, Michigan
Grand Marais, Minnesota
Jenkins, Minnesota
Park Rapids, Minnesota

The accompanying Figure 5 depicts average number of attacks per tree for the trees grown from seed introduced into Cloquet from the above locations.

Briefly, the curves maintain a fairly uniform slope throughout the three year period, possibly indicating a predisposition to attack by this species for those trees representing the higher end of the curves.

It would be unwise to attach undue significance to results which represent such a short period of time. Too, the trees within each seed source category are diverse with respect to age, size and vigor. They are presented with all these limitations clearly in mind, and are intended to suggest only that additional work along these lines might be profitable.

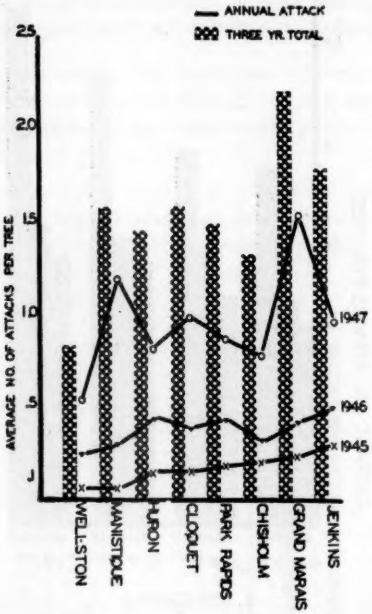

FIG. 5. Average number of attacks per tree for a three year period on trees grown from eight different seed sources.

Summary

Eucosma sonomana (Kearfott) is a small moth of the sub-family Eucosminae, family Olethreutidae. The larvae bore into the pith of the new growth of jack pine and when their development is almost completed, girdle the shoot so that breakage occurs. Pupation takes place in the litter at the base of the tree, and the insect overwinters as a pupa. In 1947 pupation took place during the last week in July and the first ten days in August. Maximum adult activity appeared to take place during the latter part of May in 1947 and the third week of May in 1948. The duration of the egg stage, based upon time of maximum adult activity and discovery of the first instar larvae, is estimated to be from three to four weeks.

Notes are included for two additional species of the sub-family Eucosminae, *Petrova albicapitana* (Busck) and *Petrova pallipennis* (McDunnough). The larvae of *P. albicapitana* form pitch blisters at the base of new jack pine shoots. The insect overwinters as a larva, pupates in the blister and emerges as an adult in the early part of June, based on observations made in 1947.

Petrova pallipennis mines the terminal buds of jack pine, spending the winter in the large central bud of the terminal group as a larva. In the second or third week of May in 1948, the larvae had broken dormancy, and pupation was completed by the first week in June. Adult activity in 1948 was at its highest point by the third week of June.

A brief analysis is included of some ecological factors influencing the incidence of attack by *E. sonomana*. Briefly, the population increase expressed in terms of average number of attacks per tree over the three year period for which

figures are available bears a straight-line relationship to tree age and size, and there is no indication that the build-up of this species is adversely affected by natural controls at this time.

Trees growing at Cloquet from seed imported from a number of different locations in the Lake States and Canada exhibited a differential incidence in point of number of attacks per tree with respect to origin. The diversity with respect to age, size and site are not considered in this analysis, consequently it may have very little significance.

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The Use of a Fluorescent Material for Marking and Detecting Insects[1]

By A. J. MUSGRAVE, B.Sc., M.Sc., A.R.C.S., D.I.C.
Dept. of Entomology and Zoology, Ontario Agricultural College, Guelph, Ont.

In the course of some studies on chemical control of pests of legume crops it has become desirable to mark honey bees at the hive and, if possible, at the flower. Considerable success has been achieved by the use of the compound fluorescein. It has been found that bees can be dusted with small quantities of fluorescein and that the presence of the material can subsequently be detected by means of a Coleman photofluorometer and by eye. It seems likely that quantitative measurements could be made with a photofluorometer.

Bees have been dusted with fluorescein in the laboratory; they have been made to pick up fluorescein by placing a fluorescein dusted wire network frame, of appropriate mesh, at the hive exit; and they have been captured after visiting fluorescein dusted dandelions. So far the fluorescein has been most delicately detected by soaking the bees for 30 minutes (2 minutes is often long enough) in a .15% solution of sodium hydroxide in water. Florescein dissolved in this can be detected in the Coleman photofluorometer, using the B_1 and PC_2 filters, by a small needle deflection, at a strength of .00001% or as .000001 gms. fluorescein, as readings are made with 10 ml. of solution.

Honey bees seem normally to be nonfluorescent, and such slight fluorescence as is given by pollen suspensions can be allowed for or shielded by filters.

Fluorescein seems to be toxic to bees if used in massive doses and appears to encourage closing of the dandelion inflorescence.

The method shows considerable promise, however, especially as it is not confined either to honey bees or to fluorescein. The work is being continued and will be reported in full.

[1]Part of the Ontario Government Legume Research Program.

Biology and Seasonal History of *Pleurotropis utahensis* Crawford, a Parasite of the Wheat Stem Sawfly[1]

By C. L. Neilson

Dominion Entomological (Field Crop Insect) Laboratory
Kamloops, B.C.

Pleurotropis utahensis Crawford was first reported as a parasite of the wheat stem sawfly, *Cephus cinctus* Nort., by Crawford (2) prior to 1913. It has been recorded by Crawford (2) from Kimball and Salt Lake City, Utah; by Ainslie (1) from North Dakota; and by Gahan (5) from Missoula, Montana. It is one of several parasites of the wheat stem sawfly in the Prairie Provinces of Canada, where it has been recorded (7) (8) as far west as Sylvan Lake, Alberta. Criddle (3) (4), and in his original notes, records it from as far east as Boissevain, Manitoba. During the present study this parasite has been collected from sufficient locations that one might assume that it occurs throughout the area where wheat stem sawfly is found (6) in Alberta, Saskatchewan, and Manitoba.

Hosts and Host Plants

P. utahensis has two known hosts. Crawford (2) states that the holotype female was reared from *Agromyza parvicornis* (Loew). The data presented here concern only the host *Cephus cinctus*, of which it is an internal larval parasite. It has been reared from this host feeding in the following plants: *Bromus inermis* Leyss., *Agropyron smithii* Rydb., *Agropyron trachycaulum* (Link) Malte [= *A. pauciflorum* (Schwein)], *Phleum pratense* L., *Stipa viridula* Trin., *Secale cereale* L., and fall rye. Criddle (3) says it was common in the grasses *Bromus inermis* Leyss., *Agropyron trachycaulum* (Link) Malte var. *typicum* Fern. [= *A. tenerum* Vassey], *Agropyron trachycaulum* (Link) Malte var. *unilaterale* (Cassidy) Malte [= *A. richardsonii* Schrad.], and *Elymus canadensis* L. It has also been reared from sawfly found in *Triticum aestivum* L. [=*T. vulgare* L.] varieties: Garnet, Thatcher, Red Bobs, Marquis, and Rescue. The fact that *Pleurotropis* readily parasitizes sawfly larvae in grasses but parasitizes the larvae in wheat only to a very limited degree has been noted by Ainslie (1) and Criddle (3). These observations were substantiated in 1939 at Pearce, Orton, and Nobleford, Alberta. Parasitism of sawfly was 50 to 70 per cent in roadside stands of the grasses *Bromus inermis*, *Agropyron smithii*, and *Agropyron trachycaulum*; but in adjoining wheat fields, which were from 75 to 90 per cent infested, there was not more than 1 to 2 per cent parasitism. In 1946 at Pearce, Alberta, an 80 per cent sawfly infestation in *Agropyron smithii* was parasitized slightly over 50 per cent whereas a similar sawfly infestation in wheat, which was not more than 10 feet distant, was parasitized less than 2 per cent. At Champion, Alberta, in 1946 the parasitism was 75 per cent in a stand of *Bromus inermis* and *Agropyron smithii* which was approximately 95 per cent infested by sawfly. In the adjoining wheat with a similar sawfly infestation, parasitism was less than 2 per cent.

From 1935 to 1946, inclusive, various collections of sawfly-cut stubs of spring wheat and of the grasses *Bromus inermis*, *Agropyron smithii*, and *Agropyron trachycaulum* have been made to determine the number of *P. utahensis* that mature from the single sawfly larva in a stub. Table 1 shows the results of some of these collections.

1Contribution No. 2622, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

TABLE 1. *Numbers of* P. UTAHENSIS *Developing in Single Sawfly Larva from Different Host Plants*

Host Plant	Stubs examined	Maximum *P. utahensis* per stub	Mean Number *P. utahensis* per stub
A. smithii	51	12	5.54
A. trachycaulum	49	9	4.32
B. inermis	65	7	3.98
Spring wheat	16	7	3.00

The one very noticeable fact from the examination of Table 1 is the higher mean number of *P. utahensis* reared from sawfly larvae in the native *Agropyron* grasses and particularly in *Agropyron smithii*, which is the more common in the sawfly-infested areas.

Ainslie (1) records a maximum of 12 *P. utahensis* per stub in grasses in Utah near Salt Lake City, but says that 5 or 6 is the more common number.

Stage of Host Attacked

The correlation of the life-history of *P. utahensis* with its host, *C. cinctus*, is shown in Fig. 1. The parasite attacks the egg and the first, second, and third larval stages of its host. The first—and second—instar sawfly larvae are more heavily parasitized than are those of the third instar. On only one occasion was a parasite egg dissected from a sawfly egg, but in this case it appeared normal in every respect, with the embryo well developed. Whether or not such parasites reach maturity is not known.

Adult Emergence, Mating, and Parthenogenicity

The adult *P. utahensis* escapes from the stub usually by chewing a circular hole through the "frass" plug which seals the end of the stub, though occasionally this hole is cut through the side of the stub. Mating occurs when the female is at rest on a stem. It is preceded by a period of "courtship" by one or several males, during which process the wings of the male are held almost vertical to his thorax and are kept in a constant flutter. Mating is completed in from one to four seconds.

It is unlikely that *P. utahensis* is parthenogenetic. In experiments in which only unmated females were caged separately over sawfly-infested grasses, the sawflies were not parasitized, whereas when both male and female parasites were caged over sawfly-infested grasses the sawflies were parasitized.

Pre-Oviposition Period

An experiment to ascertain the length of the pre-oviposition period was conducted in 1946. Pupae of *P. utahensis* were collected in the field, brought into the laboratory and reared individually in cotton-stoppered glass shell vials. As the adults emerged the females were kept in these vials without food, and then preserved in Hood's solution at 2, 4, 6, 8, 10, and 12-day intervals after emergence. They were dissected and examined for egg development. None showed any development of the oocytes. Similarly, females, after having been kept without food at 5°C., 10°C., and 25°C. and 80 per cent relative humidity for 21 days, showed no egg development. This lack of egg development may be linked with feeding habits or environmental conditions.

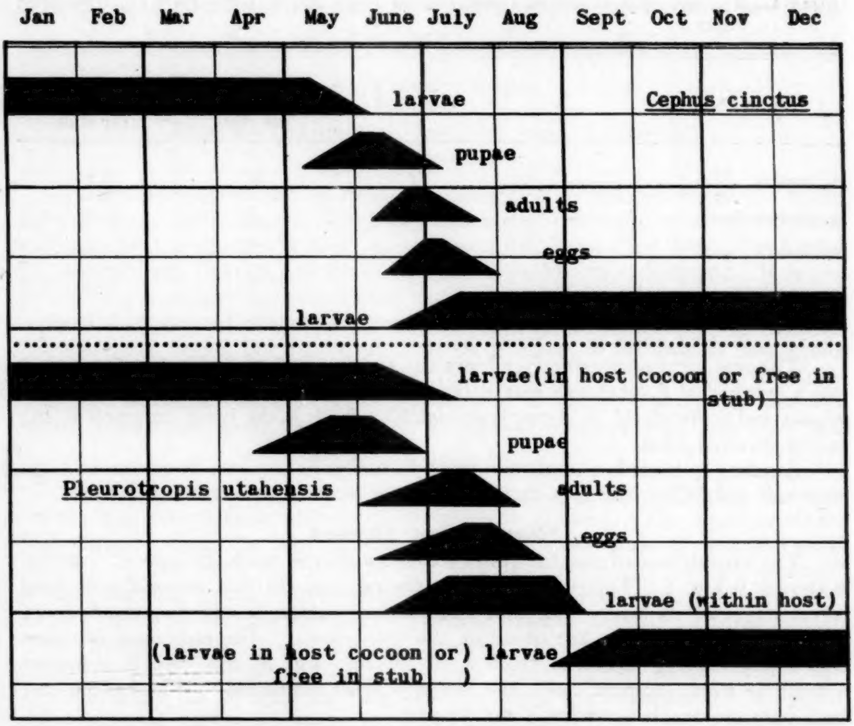

Fig. 1 Correlation of Life History of Pleurotropis utahensis Cwfd. with its Host Cephus cinctus Norton.

When a female has selected a stem in which to oviposit, she apparently ascertains the exact position of the host within the hollow stem by the use of her antennae. The ovipositor is then quickly inserted through the stem wall of the plant and the egg or eggs are deposited in the fatty tissue of the host larvae. The eggs hatch in not more than 4 to 5 days.

The reproductive potential of a single female is not known, but as many as 30 eggs have been dissected from one individual. This female was reared from a grass stub collected in the field on June 25, 1946. She was dissected on July 11, but at this date the flight had been under way for approximately 7 to 10 days in the rearing cage, so that it is possible that some eggs had already been laid.

Reaction to Temperature and Moisture

Under field conditions, periods of rainfall and accompanying lower temperatures reduced the activity of *P. utahensis.* After a rainfall of .95 inches there was no appreciable parasite activity for 48 hours until the grass was again dry, despite the fact that the sun was shining all afternoon of the day following the rain, and the grass was fairly dry.

In order to determine the probable effect of prolonged cold or prolonged periods of high temperature and humidity, on adults in the field, freshly emerged individually reared adults were placed at various temperatures. There was little

difference in the mortality rates of adults kept at constant temperatures of 5°C. and 10°C. at the end of 48 days. Those maintained at 25°C. and 80 per cent relative humidity suffered a 19 per cent mortality after 21 days as compared with 100 per cent mortality at 25°C. and 90 per cent relative humidity for the same period. Though such constant temperatures do not occur under field conditions, the results suggest that the length of adult life of *P. utahensis* may vary considerably from year to year and from one locality to another, depending on the weather conditions of the particular area. Larvae collected from *A. smithii*, at Pearce, April 11, 1946, were subjected to low temperatures by Dr. R. W. Salt (8) at the author's request. As the larvae were too small to cause a rebound on a single thermocouple, the indirect method was used. The fact that the undercooling point lies close to -22.5°C. for larvae collected this time of year tends to confirm the opinion that freezing is not a big factor in mortality, even in the areas of chinook winds, where sudden warmth followed by freezing often occur in the winter and spring.

Flight

Both male and female *P. utahensis* are positively phototropic. They are weak fliers; they do not seem to fly for sustained periods, usually flying just from one stem to another in close proximity.

The maximum period of flight of *P. utahensis* observed in southern Alberta lasted from the first week of June until the first week of August (Fig. 1). However, there are undoubtedly variations as a result of the widely varying soil types and climatic conditions. The peak of the flight usually occurs during the last days of June and the first few days of July. The peak of the parasite flight period is only 7 to 12 days later than the peak of the flight of sawflies emerging from native grasses, but is at least two weeks later than the peak of the flight of sawflies emerging from wheat. Thus the peak of the flight of *P. utahensis* occurs at a time when the larvae of *C. cinctus* in wheat are in the second, third, and fourth instars, but are chiefly in the first and second instars in the native grasses.

Sex Ratio

The sexes of the adult *P. utahensis* reared during several experiments were recorded and are shown in Table 2. Though the data are from a small number of individuals they are presented to show that there are some differences in the sex ratio of the parasites emerging from sawfly larvae from different host plants.

TABLE 2. *Sex Ratio of* P. UTAHENSIS *emerging from Sawfly Larvae from Host Plants when Reared at Constant Temperatures*

Host Plant of *C. cinctus* from which *P. utahensis* was reared	Females	Males	Ratio ♀/♂
Bromus inermis....................	32	14	2.28
*Bromus inermis**....................	9	5	1.80
Agropyron smithii....................	29	7	4.14
Agropyron trachycaulum..............	36	10	3.10

*Reared at a constant temperature of 55.4°F. All others were reared at 77°F. and 80 per cent relative humidity.

In any single stub which contained more than one *P. utahensis* the adults were either all female or both male and female. In no instance were only males recorded from a single stub.

Larval and Pupal Development

Upon hatching, the parasite larvae develop within the sawfly larva until fall and then by means of tiny punctures pass through the host skin into the stem lumen. Occasionally this movement occurs before the sawfly larva has cut the plant and has been observed to have taken place as early as September 9, but usually the parasite larvae kill the host and migrate through the skin into the lumen after the sawfly larva has cut the stem and spun its cocoon. In either case the developing parasites feed on the host tissue, completely devouring everything except the larval skin, head capsule, and mouth parts. Having escaped from the host larva, the *P. utahensis* larva overwinters in the host cocoon within the "stub" and is thus afforded protection below the ground level throughout the winter.

Prepupal and pupal development occurs in the "stub", beginning with rising spring temperatures. Pupation usually starts during the last two weeks of April, but some individuals may be found pupating as late as the last week of June. Just prior to pupation the gut is emptied and the faeces appear as a series of round, brown pellets which are often joined together. All pupae within a single stub do not mature simultaneously. For example, the examination of a stub of *Agropyron smithii* revealed the following specimens ranging from the top to the bottom of the stub: 2 adults, 1 pupa, 1 adult, 1 pupa. In other stubs both coloured and uncoloured pupae may be found, and there seems to be no correlation between their stages of development and their location within the stub.

In order to determine the time necessary for the completion of larval and pupal development, specimens were reared through both of these stages in the laboratory. In the fall of 1938, just before the ground became frozen, a collection of *Bromus* stubs was made at Orton, Alberta, and stored in the laboratory at 6°C. to simulate field conditions during the winter. On January 12, 1939, these stubs were split and the larvae reared individually in cotton-stoppered glass shell vials, in a constant temperature cabinet at 77°F. and 80 per cent relative humidity. The results are shown in Table 3.

On March 22, 1939, another collection was taken from the same location and reared by the same method at a constant temperature of 55.4°F. The mean temperature on the day of the collection was 54.7°F. The mean maximum temperatures for March, April, and May, 1939, were 41.5°F., 57.8°F., and 67.2°F., and the mean minimum temperatures for the same three months were 16.2°F., 30.4°F., and 42°F. respectively. The results of these rearings are also shown in Table 3.

TABLE 3. *Period of Development of* P. UTAHENSIS *taken from* BROMUS INERMIS *and reared at Constant Temperatures.*

	55.4°F.		77°F. & 80%	
No. Larvae used	60		20	
No. larvae that pupated....	47		15	
	Mean	Range	Mean	Range
No. days as larvae	17.5	16–32	18.5	15–35
No. days as pupa	20.2	16–32	13.1	12–15

Two similar experiments were carried out in 1946, one with *P. utahensis* larvae collected from *A. smithii* at Cayley, Alberta, on March 26, the other with larvae from *A. trachycaulum* collected at Pearce, Alberta, on March 14. The results are shown in Table 4.

TABLE 4. *Period of Development of* P. UTAHENSIS *from Different Host Plants at a Constant Temperature of 77°Fahrenheit and 80 per cent Relative Humidity, 1946.*

Host Plant	*Agropyron smithii*		*Agropyron trachycaulum*	
No. individuals in experiment	36		46	
	Mean	Range	Mean	Range
Number per stem	3.9	1–7	3.4	1–9
Days in larval stage	12.6	11–19	12.8	11–13
Pigmentation period	3.0	–	2.9	6
♀♀ days in black pupal stage	9.1	4–16	5.4	3–10
♂♂ days in black pupal stage	8.0	4–14	6.3	3–15

The only difference in the time of development of the parasites in these two host plants seems to be in the black pupal stage. Both males and females took 2 to 3 days less to complete development in *A. trachycaulum* than in *A. smithii.* The reason for this is not understood.

Discussion

There is a decided preference shown by *Pleurotropis utahensis* Cwfd. to parasitize sawfly in grasses rather than in the wheat varieties commonly grown in Western Canada. The exact nature of this host preference is not known. In the light of many observations made during this study it is difficult to arrive at any theory regarding this host preference. The growth habit of the wheat plant should not prevent the parasite from readily attacking the sawfly larvae in it. As the stem of the wheat plant is usually as soft as that of the grasses, it apparently can be penetrated by the ovipositor. The ovipositor is of sufficient length to penetrate the wall of the wheat stem, and as the parasite has access to all sides of the stem it should be able to parasitize the sawfly larvae. Fig. 1 shows that there is a sufficient overlap of egg and larval instars of the sawfly in wheat so that host availability at any given stage of development in wheat is not a controlling factor. This then eliminates lack of a suitable host and inability of the parasite to penetrate the wheat plant in order to deposit eggs. It is believed that the cause is closely linked with a combination of factors: method of movement, and temperature, humidity, and food requirements of adult parasites. The primary method of movement is by very short rather than sustained flights, and parasites emerging from grasses are more likely to stay in these grasses rather than move further to adjacent wheat fields. *P. utahensis* occurs in greatest abundance in heavy stands of native grasses, especially when these stands are in barrow pits or depressions where water accumulates occasionally. Such stands provide a very humid atmosphere and stems in close proximity, both of which appear to favour increased parasitism. From the results obtained during the pre-oviposition studies it is possible that adult feeding on grasses is essential to complete egg development. If this is the case, then the combination of feeding habits and method of flight or movement play the most important role in determining host selection by the adult *P. utahensis.*

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Notes on Two *Incisalia* Types (Lepidoptera, Lycaenidae)

By CYRIL F. DOS PASSOS

Mendham, New Jersey

Incisalia hadros Cook and Watson, and *Incisalia Henrici*, G. & R., new variety, *solatus* Cook and Watson, were described in *The Canadian Entomologist*, 1909, volume 41, pages 181-182.

In the description of *hadros* it was stated that the types (♂ and ♀) and two paratypes (♂ and ♀) would be sent to the United States National Museum. The description of *solatus* did not mention the disposition of the types.

Some years ago while photographing the types of Nearctic Lepidoptera in the United States National Museum, the types of *hadros* and *solatus* could not be found. Recently Mr. William D. Field of the United States Department of Agriculture made a further search for these types. Later he wrote stating that the types were not there, but that they do have male paratypes, number 4 and number 15, of *hadros*, the former having been received from the Brooklyn Museum.

The matter then was taken up with the authors of these names, and the senior author, Mr. John H. Cook, recalled that the late Dr. Harrison G. Dyar, then in charge of Rhopalocera at the United States National Museum, wrote him that the types had been damaged badly in transit. Mr. Cook further advised me that the type of *solatus* was in the same shipment and suffered like fate, and that he had no second specimen to send. At Dyar's request the above mentioned male paratype, number 15, of *hadros* was sent to Washington at some later date to replace the destroyed types and paratypes.

In view of the fact that the types of these two names were destroyed, the male paratype of *hadros* in the United States National Museum, bearing number 15, hereby is designated the lectotype of *Incisalia hadros* Cook and Watson, and will be labeled accordingly. A male paratype of *solatus* in the collection of Mr. William P. Comstock, bearing number 2, hereby is designated the lectotype of *Incisalia Henrici*, G. & R., new variety, *solatus* Cook and Watson, and will be likewise labeled. Mr. Comstock will deposit this lectotype in the American Museum of Natural History.

In circumstances such as herein disclosed, it would have saved considerable trouble if Dyar had retained the pin labels that were attached to the types of *badros* and *solatus*, and added labels of his own recording the destruction of the types. In this case, fortunately, it was not too late to ascertain the facts, but there must be many similar cases where that no longer can be done, and such labels would dispel any doubt as to what actually happened to the types.

Book Review

By W. S. McLeod

The Mode of Action of Organic Insecticides, by Robert L. Metcalf, University of California (Riverside.) 84 pp. The Chemical-Biological Coordination Centre, National Research Council, Washington, D.C., 1948. $1.00, including postage.

This is Review No. 1 of the Chemical-Biological Coordination Centre. It confines itself to those organic insecticides on which comprehensive data on properties and modes of action are at hand. The chapter headings are: Nicotine, Pyrethrum, Rotenone, Organic Thiocyanates, Dinitrophenols, Phenothiazine, Dichlorodiphenyltrichloroethane, Benzene Hexachloride, and Organic Phosphates.

A brief review of the chemistry of each material is presented in order to make the discussion of toxicological, physiological, and biochemical information more intelligible. Metcalf confines his discussion to the effect of these materials on insects only, choosing his topics according to the available literature. In general, however, he deals with the relative toxicity of the materials and their isomers or closely related materials, their mode of entrance into the insect body, mode and locus of action within the body, and biochemical and physiological effects. In the case of pyrethrum, a section on synergism is included.

Over 300 references are cited. Emphasis has been placed, according to the author, on papers which best represent major contributions and modern points of view. Works of merely historical interest have been omitted.

This review is a most valuable contribution to the study of organic insecticides, and it is hoped that the Coordination Centre will soon publish other contributions of equal merit.

The bald-faced hornet, *Dolichovespula maculata* (L.), as a predator of the white-grub parasite *Microphthalma disjuncta* Wied. in Hastings County, Ontario.

On June 20, in a rough pasture field near Madoc which had been seriously damaged by second-year grubs of June beetles, *Phyllophaga* spp., during the previous year, many adult males and females of the internal parasite *Microphthalma disjuncta* Wied. were observed in flight. They were abundant and very active, moving in short, rapid hops. It was apparent that the maximum concentrations of parasitic flies occurred over the foliage of low-growing plants scattered irregularly over the field. One ground juniper, *Juniperus communis* L., in particular was observed to have a swarm of flies hovering over the top foliage. Into this swarm of flies the bald-faced hornet, *Dolichovespula maculata* (L.), swooped at intervals of some minutes, carrying off a parasitic fly in each case, presumably to provision the nest. During years of abundance of the bald-faced hornets they could assume some importance as an undesirable predator.—G. H. Hammond (Marmora, Ont.)

Eighty-sixth Annual Meeting, The Entomological Society of Ontario

On the invitation of the Entomological Society of Manitoba, the eighty-sixth annual meeting of the Entomological Society of Ontario will be held in Winnipeg, November 2, 3 and 4. Headquarters for the meeting will be the Fort Garry Hotel. The Manitoba Society is in charge of the program and will act as host to the Ontario Society.

The decision to hold the meeting in Winnipeg was prompted by the desire of the Board of Directors and Council to continue to promote the proposal for a national society. It was felt that at this central location, a meeting of truly national character would result; present indications are that good representation from both Eastern and Western Canada may be expected.

The circumstances of this meeting permit certain innovations in the traditional form of the program. The popularity of the symposia featured at the Montreal meeting suggests that the members are interested in a broader approach to entomological problems than is possible in the usual short paper. For this reason, the Program Committee has prepared a program based largely on invitation papers and symposia. A session of short papers is provided. The program will also feature exhibits and demonstrations of entomological techniques and research equipment.

The program is presented below and the following points particularly are drawn to the attention of prospective delegates.

Submission of Titles for Papers

Delegates are invited to submit titles of papers for presentation at the meeting. Titles should be accompanied by a brief summary of the content of the paper and a statement indicating the size of projector required, if any. Authors will be limited to 15 minutes for presentation and discussion of their papers. All submissions must be in the hands of the undersigned *before October 1.*

The Program Committee will group the submitted titles into sections which will run simultaneously as separate sessions. The number and types of grouping cannot be anticipated until all titles are received. If possible, all groups will meet in one building on the campus of the University of Manitoba so that attendance at more than one group will be facilitated.

Exhibits and Demonstrations

Suggestions are invited for exhibits and demonstrations from individuals or institutions prepared to set them up. The nature of the exhibit or demonstration should be stated together with the minimum space required. Suggestions must be in the hands of the undersigned *before October 1.*

The following suggestions have been received:

Demonstration of the use of radio-active tracers for studying movement of soil insects.—R. A. Fuller, Saskatoon.

Cytogenetic methods for the rapid separation of closely related species. Miss Dever, Belleville.

Exhibit of electron micrographs of insect cuticle.—A. Glen Richards, U. of Minnesota.

Demonstration of equipment for measuring the di-electric constant of insects.—F. L. Watters, Winnipeg.

Demonstration of the precipitin reaction method.—J. G. Rempel, U. of Saskatchewan.

Exhibit of sawfly resistance in wheat.—C. W. Farstad, Lethbridge.

Demonstration of a spray tower assembly.—B. N. Smallman, Winnipeg.
Exhibits by the insecticide industry.
Exhibits by scientific instrument companies.

Hotel Reservations

The Fort Garry Hotel has undertaken to accommodate all delegates to the meeting. The luncheon, banquet, and all meetings except one will be held in this hotel. Reservations should be made *before October 1* by writing directly to the hotel, and should refer to the meeting of the Entomological Society of Ontario. The Program Committee requests that delegates forward a copy of their letter of reservation to the undersigned.

The following rates are available from the Fort Garry Hotel and from two other hotels within 10 minutes walk of the Fort Garry.

Fort Garry Hotel:	Single	4.50 up
	Double	6.50 up
Marlborough Hotel:	Single	3.50 up
	Double	5.50 up
St. Regis Hotel:	Single	3.50 up
	Double	4.50 up

Signed,
B. N. Smallman,
Chairman, Program Committee,
724 Dominion Public Bldg.,
Winnipeg.

The Program

TUESDAY, NOVEMBER 1
Fort Garry Hotel

3.00 P.M.
Meeting of the Directors
8.00 P.M.
Meeting of the Council

WEDNESDAY, NOVEMBER 2
MacDonald Room, Fort Garry Hotel

9.00 A.M.
Registration
10.00 A.M.
Business Session
11.00 A.M.
Address of Welcome
Honourable D. L. Campbell, Premier, Province of Manitoba.
Lt.-Col. C. A. S. Smith, President, Entomological Society of Manitoba.
Presidential Address
Dr. G. M. Stirrett, Kingston, Ontario.
12.00 Noon
Luncheon
Speaker: Professor R. A. Wardle, University of Manitoba.
1.30 P.M.
Virus Diseases of Insects—Dr. G. H. Bergold, Sault Ste. Marie.
2.30 P.M.
The Measurement of Meteorological Factors Affecting Insects.—Dr. W. G. Wellington, Sault Ste. Marie.

3.30 P.M.

SYMPOSIUM: Selective Breeding of Plants and Insects for Pest Control.
Chairmen: Dr. C. W. Farstad, Lethbridge.
Dr. A. Wilkes, Belleville.

9.00 P.M.

Entomologists' Smoker

THURSDAY MORNING, NOVEMBER 3
University of Manitoba, Fort Garry Campus
(Building to be designated)

9.00 A.M.

Session of Short Papers
(Sections, titles and authors to be listed on final program)

THURSDAY AFTERNOON
MacDonald Room, Fort Garry Hotel

2.00 P.M.

Entomological Studies in the Canadian Arctic.
Studies of the Biology and Control of Biting Flies.—Dr. C. R. Twinn, Ottawa.
Insect Survey.—Dr. T. N. Freeman, Ottawa.

3.00 P.M.

Exhibits and Demonstrations

4.00 P.M.

SYMPOSIUM: The Preparation of Scientific Papers.
Chairman—Dr. B. N. Smallman, Winnipeg.

6.00 P.M.

Reception. Drawing Room, Mezzanine.

7.00 P.M.

Banquet. Jade Room
Speaker: Dr. J. A. Anderson, Chief Chemist, Grain Research Laboratory, Winnipeg. "The Scientific Method".

FRIDAY, NOVEMBER 4

9.00 A.M.

Role of Insect Physiology in Applied Entomology.—Dr. A. Glen Richards, University of Minnesota.

10.00 A.M.

Exhibits and Demonstrations

11.00 A.M.

Recent Advances in Insect Toxicology.—Dr. H. Hurtig, Suffield.

1.30 P.M.

SYMPOSIUM: Systematics.
Chairman—Dr. C. E. Mickel, University of Minnesota.
Theory and Application.—Dr. E. Munro, MacDonald College.
The Role of Morphology.—Mr. W. J. Brown, Ottawa.
The Role of Cyto-genetics.—Dr. S. G. Smith, Sault Ste. Marie.

3.00 P.M.

Exhibits and Demonstrations

4.00 P.M.

Final Business Session

THE RUNGE PRESS LIMITED, OTTAWA
Mailed: Tuesday, October 25th, 1949